and the disk of *Venus* would be undiscernible by the observer on the Earth, because the rays from the inside of the ring, really proceeding from the part of the Sun opposite to (that is, most remote from) the place of contact, would not pass more than a mile or two above the surface of *Venus*, on any probable hypothesis as to the refractive power of the planet's atmosphere.* The bright spot near the pole (assuming for the moment that we know the true axial position of *Venus*) might be explained as indicating clearer air over the planet's polar regions.

It was to be expected that this ring of light would be bright—brighter even than the Sun's limb. Maskelyne, in his account of the Transit of 1769,† as seen at Greenwich, recorded enough to show that *Venus* has an atmosphere, and that with a good telescope the bright ring would always be seen round the dark part of the limb, thus preventing the *exact* timing of internal contact.

London, 1875, *June* 10.

On the Application of the Method of Limiting Apertures to the Photometry of Naked-eye Stars. By E. B. Knobel, Esq.

In making observations with the Astrometer, which I had the honor of submitting to the Society last December, it occurred to me that if I removed the silver surface of the mirror of my telescope, I should probably be able to reduce the light of naked-eye stars so much as to convert them into virtually telescopic stars—understanding by a telescopic star, one which requires an aperture larger than the pupil of the eye for its exhibition.

Taking advantage of the silver surface being somewhat broken up, I dissolved it off, and for the past six weeks have devoted myself exclusively to observations with an *unsilvered* glass mirror.

The telescope in this form does not differ materially from the instrument called a Helioscope, devised by Sir John Herschel for solar observation; but instead of employing a prism with reflection from external surface, as he suggests, I have retained the silvered plane or flat, so that the only difference made is in the silver surface of the mirror.

Though considerable advantage would have resulted from using a prism with reflection from external surface only, for the photometrical observation of the brightest stars (a method which I hope to be able to undertake at a future time,) yet my prin-

* In considering this subject it must not be forgotten that the apparent diameter of *Venus* is increased by her atmospheric refraction.

† *Phil. Trans.* 1768, p. 367.

cipal object in not making any observations under these conditions now, was that one series made with the unsilvered mirror might be readily and with certainty compared with another made with the silvered mirror, by merely knowing the ratio of light reflected at a perpendicular incidence from polished silver and the external surface of glass—incidentally also by these two series of observations to determine this ratio with some approach to accuracy.*

Using the limiting aperture Astrometer on the unsilvered mirror, I find myself able to extinguish all stars from the 1st to the 9th or 10th magnitudes, and with the silvered mirror, stars down to the 15th magnitude.

By these means of observation, therefore, I see no reason why naked-eye and telescopic stars should not be connected in one unbroken chain, and a better idea of the relative magnitudes obtained than we possess at present.

The following observations with the unsilvered mirror I can only consider as first experiments. I much regret that my astronomical observations are likely to be interrupted for some time, and, therefore, I have no reason for delaying to submit my results to the consideration of the Society.

Mr. Dawes, in his valuable researches on the Photometry of Telescopic Stars, employed as a basis the mean limiting aperture for an average 6th-magnitude star, which he found to be ·15 inch, and upon this he built up a table of limiting apertures for stars of different magnitudes. This aperture I find, by the method I have adopted, to be about the limiting aperture for the Pole star. Circular apertures so minute as ·15 inch are necessarily very difficult to construct and very difficult to measure when made; but the same aperture by the method I propose is calculated from a triangular opening, the side of which is $1\frac{1}{2}$ inch, and by the formula given with the description of the Astrometer,† the effective aperture is accurately calculated, the only error being in any want of concentricity between the triangle and the plane of the reflector.

In this elementary stage of the subject, it is impossible to generalise and combine the results of several nights. I have, therefore, kept each night's observations quite distinct, and made comparison only between those stars observed at the same date and under similar atmospheric conditions.

The first column gives the date of observation; the second, the star's name; the third gives the mean limiting aperture taken from a table kindly prepared for me at great trouble by Mr. Gray;

* Sir John Herschel gives this ratio on the authority of Bouguer as 905 : 43. The small star which forms an obtuse angle with ϵ and 5 *Lyræ* is the only star yet examined with the silvered and unsilvered mirror, and this gives a ratio of 1000 : 125. This result, however, cannot be relied on, as it is obtained from such few observations; yet I do not think the error is very great, and am inclined to suspect that Bouguer's ratio will not hold good for the polished silver surface on a glass reflector.

† *Monthly Notices*, December 1874.

the fourth column contains the number of observations; the fifth gives the Light-ratio in terms of one star selected as a unit for each night. I append a Table of Light-Ratios of Stars to tenths of magnitudes, calculated on Pogson's ratio of the amount of light received from two stars differing in brightness by one whole magnitude = 2·512. By reference to this table the relative magnitudes of each night's series may be at once ascertained. In the sixth column I give the magnitude of the star assigned by Argelander in his *Durchmusterung*. The Star-magnitudes in this work seem to be decidedly more accurate than those given in the *Uranometria Nova.** I am confirmed in this opinion by a remark of Mr. Christie's in a recent paper on "the Brightness of Stars."† Mr. Christie selected certain standard 6th-magnitude stars, which he found Argelander called 6·0 magnitude; but his observations showed there was no such approach to equality as he had expected. On comparing, however, Argelander's magnitudes in the *Durchmusterung* with Mr. Christie's results, there is a satisfactory accordance between them for five of the seven

* The following are a few instances in support of this statement, in which U. N. shows the magnitudes assigned in the *Uranometria Nova*, and D. those of the *Durchmusterung* : L.A. being the mean limiting apertures I have obtained :—

	U. N.	D.	L. A. Inches.
17 Ursæ Majoris	6·0	5·0	·52
35 Ursæ Majoris	6·0	6·6	·81
42 Ursæ Majoris	6·0	5·8	·54
θ Ursæ Minoris	6·5	5·0	·45
26 Draconis	6·5	6·0	·54
β Coronæ	4·3	4·0	·40
ϵ Coronæ	4·0	4·0	·43

Comparing the limiting apertures shows at once a better accordance with the magnitudes of the *Durchmusterung* than with those of the *Uranometria Nova*.

I append also Mr. Christie's results compared with the magnitudes given in the *Uranometria Nova* and the *Durchmusterung* :—

	U. N.	D.	Brightness.
40 Pegasi	6·0	6·0	80·1
52 Pegasi	6·0	6·1	72·4
45 Pegasi	6·0	6·2	74·4
41 Pegasi	6·0	6·5	49·6 (Mean of two)
60 Pegasi	6·0	6·5	48·7

[It was suggested at the meeting that in the U.N. the magnitudes are given as 6, 6, 6, 6–5, 6–5, 4–3, 4 : viz. that 6–5, 4–3 mean somewhat brighter than 6, 4 respectively.—Ed.]

† *Monthly Notices*, January 1874.

1875MNRAS..35..381K

selected stars. Indeed, only one of these stars is given in the *Durchmusterung* as of the 6·0 magnitude.

A Kellner eyepiece, power 60, was employed throughout, except for μ^1 and μ^2 *Boötis*, and the 9th magnitude *comes* to ϵ and 5 *Lyræ*, when a high power was used to obviate the effect of the neighbouring bright stars.

Date 1875.	Star.	Limiting Aperture. Inches.	No. of Obs.	Light-Ratio.	Magnitude Argelander, *Durch-musterung.*
April 27	σ^2 Ursæ Majoris	0·44	2	1·000	5·3
,,	σ^1 Ursæ Majoris	0·54	2	0·640	5.2
,,	42 Ursæ Majoris	0·66	3	0·444	5·8
April 28	27 Ursæ Majoris	0·45	2	1·000	5·3
,,	θ Ursæ Minoris	0·45	2	1·000	5·0
,,	32 Ursæ Majoris	0·47	2	0·916	5·8
,,	26 Draconis	0·50	2	0·810	6·0
,,	17 Ursæ Majoris	0·52	3	0·748	5·0
,,	42 Ursæ Majoris	0·54	2	0·694	5·8
,,	6 Ursæ Majoris	0·60	4	0·562	6·0
,,	35 Ursæ Majoris	0·81	2	0·308	6·6
May 2	μ^1 Boötis	0·38	1	2·576	4·0
,,	14 Boötis	0·61	3	1·000	6·2
,,	18 Boötis	0·62	2	0·968	5·7
,,	π^1 Ursæ Minoris	0·73	3	0·698	6·8
,,	10 Can. Ven.	0·79	2	0·596	6·1
,,	7 Leonis	0·81	3	0·567	6·8
,,	3 Messier Nebula	0·85	1	0·515	Nebula
,,	163 P. xiii.	0·88	3	0·480	6·5
,,	μ^2 Boötis	0·90	1	0·459	7·0
,,	Comes to ϵ & 5 Lyræ	3·72	1	0·026	9·4*
May 9	χ Ursæ Majoris	0·32	1	14·535	4·0
,,	Arg. 1964 Zone 48°	1·22	2	1·000	7·8
,,	Arg. 1877 Zone 53°	2·18	1	0·313	9·3
,,	Arg. 1874 Zone 53°	2·30	2	0·281	9·5
,,	Arg. 1873 Zone 53°	2·36	4	0·267	9·5
,,	Arg. 1878 Zone 53°	2·52	3	0·234	9·4
,,	Comes to ϵ & 5 Lyræ	3·45	4	0·125	9·4

* Gauged by Dawes of 9·5 Mag.

Date 1875.	Star.	Limiting Aperture. Inches.	No. of Obs.	Light-Ratio.	Magnitude Argelander, *Durchmusterung*.
May 10	λ Draconis	0·30	4	1·000	3·3
,,	χ Ursæ Majoris	0·32	1	0·878	4·0
,,	ξ Draconis	0·36	3	0·694	3·5
,,	ε Lyræ	0·41	2	0·535	4·3
,,	μ^1 Boötis	0·42	2	0·510	4·0
,,	ρ Ursæ Majoris	0·42	1	0·510	5·1
,,	σ^2 Ursæ Majoris	0·43	1	0·486	5·3
,,	θ Ursæ Minoris	0·51	1	0·346	5·0
,,	σ^1 Ursæ Majoris	0·53	1	0·320	5·2
,,	μ^2 Boötis	1·05	2	0·0816	7·0
,,	13 Messier Nebula	1·20	1	0·062	Nebula
,,	Arg. 480 Zone 78°	2·81	1	0·014	0·4
,,	Arg. 1969 Zone 48°	3·18	1	0·0089	9·5
,,	Comes to ε & 5 Lyræ	3·31	1	0·0082	9·4
May 13	α Draconis	0·26	3	1·273	3·4
,,	ε Lyræ	0·31	1	1·000	4·3
,,	ξ Draconis	0·32	2	0·938	3·5
,,	ζ Ursæ Minoris	0·36	2	0·741	4·7
,,	ψ Boötis	0·38	3	0·665	4·7
,,	λ Draconis	0·39 *	2	0·631	3·3
,,	45 Boötis	0·41	3	0·571	4·8
,,	μ Draconis	0·42	2	0·544	4·8
,,	ν^1 Coronæ	0·43	2	0·519	5·2
,,	θ Ursæ Minoris	0·45	1	0·474	5·0
,,	ω Boötis	0·50	2	0·384	4·7
,,	26 Draconis	0·54	1	0·329	6·0
,,	73 Ursæ Majoris	0·55	1	0·317	6·0
,,	19 Ursæ Minoris	0·56	3	0·306	6·0
,,	38 Boötis	0·63	1	0·242	6·0
,,	6 Ursæ Majoris	0·65	2	0·227	6·0
,,	70 Ursæ Majoris	0·66	1	0·220	6·0
,,	Comes to ε & 5 Lyræ	3·26	1	0·0090	9·4
May 15	Arcturus	0·040	3	30·250	1·0
,,	α Lyræ	0·058	3	14·387	1·0
,,	γ Draconis	0·22	2	1·000	2·2

* Affected by bright moon.

Date 1875.	Star.	Limiting Aperture. Inches.	No. of Obs.	Light-Ratio.	Magnitude Argelander, *Durchmusterung*.
May 15	χ Draconis	0·27	3	0·663	3·8
,,	δ Draconis	0·28	2	0·617	3·4
,,	α Draconis	0·30	4	0·537	3·4
,,	ι Draconis	0·30	2	0·537	3·0
,,	ι Herculis	0·32	4	0·472	4·0
,,	ξ Draconis	0·33 *	1	0·444	3·5
,,	φ Draconis	0·33	2	0·444	4·7
,,	ξ Draconis	0·35 †	2	0·395	3·5
,,	ψ Draconis	0·39	2	0·318	4·8
,,	ψ Boötis	0·49 ‡	1	0·201	4·7
,,	ω Boötis	0·56 ‡	1	0·154	4·7
,,	45 Boötis	0·59 ‡	1	0·139	4·8
May 16	Arcturus	0·047 §	8	1·000	1·0
,,	α Lyræ	0·064	11	0·529	1·0
,,	α Cygni	0·097	8	0·234	1·7
,,	β Ursæ Minoris	0·145	8	0·105	2·1
,,	Polaris	0·154	8	0·093	2·0
May 31	ε Lyræ	0·38	2	1·000	4·3
,,	μ^1 Boötis	0·46	6	0·682	4·0
,,	ψ Boötis	0·48	4	0·626	4·7
,,	ω Boötis	0·56	3	0·460	4·7
,,	μ^2 Boötis	1·12	1	0·115	7·0
June 1	ζ Ursæ Minoris	0·32	3	1·000	4·7
,,	δ Ursæ Minoris	0·33	3	0·940	4·5
,,	ε Ursæ Minoris	0·33	3	0·940	4·0
,,	5 Ursæ Minoris	0·38	3	0·709	5·0
,,	μ^1 Boötis	0·40	4	0·640	4·0
,	η Ursæ Minoris	0·41	2	0·609	5·3
,,	4 Ursæ Minoris	0·44	2	0·528	5·0
,,	ψ Boötis	0·50	3	0·409	4·7
,,	45 Boötis	0·50	2	0·409	4·8
,,	19 Ursæ Minoris	0·51	3	0·393	6·0
,,	ω Boötis	0·58	2	0·304	4·7

* Unaffected by moon.
† Affected by moonlight.
‡ Strongly affected by moonlight.
§ Moon 30° from *Arcturus*, affecting it more than α *Lyræ*.

Date 1875.	Star.	Limiting Aperture. Inches.	No. of Obs.	Light-Ratio.	Magnitude Argelander, *Durch-musterung.*
June 4	α Coronæ	0·24	3	1·000	2·0
„	γ Coronæ	0·35	3	0·470	4·0
„	θ Coronæ	0·36	3	0·444	4·2
„	β Coronæ	0·40	3	0·360	4·0
„	ϵ Coronæ	0·43	4	0·311	4·0
„	δ Coronæ	0·50	4	0·230	4·5
„	ι Coronæ	0·59	4	0·165	5·0
„	η Coronæ	0·66	4	0·132	5·2

April 27. Fair night; little haze; no moon.
„ 28. Very fine night; remarkably clear.
May 2. Fair night; little haze.
„ 9. Fine bright night; west wind.
„ 10. Fine and steady; Moon's age, five days.
„ 13. Bright moon, eight days old.
„ 15. Moon very bright, ten days old.
„ 16. Fair night; east wind; bright moon.
„ 31. East wind; haze; observations difficult from ill health.
June 1. Fine clear night; east wind.
„ 4. Hazy night; westerly wind.

Several anomalies and contradictions are almost inseparable from such observations, which I attribute rather to physiological than to atmospheric causes, but with the majority of cases a satisfactory accordance will be found.

The two stars μ^1 and μ^2 *Boötis* were examined on three nights, giving a difference of magnitude of 1·9, 2·0, and 1·9 respectively, Smyth makes a magnitude-difference of 4·0, and Argelander 3·0 between these stars: both estimates are quite irreconcilable with what I have obtained. ξ *Draconis* and the 9th-magnitude star which forms an obtuse angle with ϵ and 5 *Lyræ* gave a magnitude-difference of 4·8 one night and 5·0 on another. χ *Ursæ Majoris* and the same small star gave magnitude-differences on two nights of 5·1 and 5·0 respectively.

The two stars ψ and ω *Boötis* gave on three out of four the same magnitude-difference, viz.: 0·3. These stars are rated by Argelander of exactly equal magnitudes.

14 *Boötis* and 18 *Boötis* were gauged of the same magnitude, and on that night there was no apparent difference to the naked eye. Argelander makes 0·5 magnitude-difference between them, and in Proctor's *Atlas* they are marked one of the 5th and the other of the 6th magnitude. As these stars are close together and eye-comparison is easy, it is difficult to understand the discrepancy even of half a magnitude, unless there has been

change: it is, therefore, possible that the star 14 *Boötis* may turn out to be a variable.

Comparison made between observations of *Arcturus* and *Vega* on two nights, gave on May 15, a magnitude-difference of 0·8; and on the following night, from a larger series of observations, but when *Arcturus* was more affected than *Vega* by the neighbouring moon, a magnitude-difference of 0·7.

I do not think much weight can be given to the *actual* limiting apertures, which are very minute for these particular stars, as any want of concentricity in the triangular opening and the diagonal plane of the telescope would affect them so largely. I do not think, however, there is much error in the *relative* apertures, and, consequently, in the relative magnitudes.

But the consideration of stars of the first magnitude may be better left to the observations I hope to be able to undertake, reducing the light still more, by using, in the place of the diagonal plane, a prism, with reflection from external surface only, and thus necessitating a larger limiting aperture.

Stapenhill, Burton-on-Trent,
1875, *June* 5.

Table of Light-Ratios of Stars in terms of a 6th-Magnitude Star.
Pogson's ratio $R=2{\cdot}512$.

Mag.	L.R.	Mag.	L.R.	Mag.	L.R.
1·0	100·000	5·1	2·291	9·2	0·05249
1·1	91·210	5·2	2·090	9·3	0·04787
1·2	83·190	5·3	1·906	9·4	0·04366
1·3	75·870	5·4	1·738	9·5	0·03981
1·4	69·190	5·5	1·585	9·6	0·03631
1·5	63·100	5·6	1·445	9·7	0·03312
1·6	57·550	5·7	1·318	9·8	0·03020
1·7	52·490	5·8	1·202	9·9	0·02755
1·8	47·870	5·9	1·096	10·0	0·02512
1·9	43·660	6·0	1·000	10·1	0·02291
2·0	39·810	6·1	0·9121	10·2	0·02090
2·1	36·310	6·2	0·8319	10·3	0·01906
2·2	33·120	6·3	0·7587	10·4	0·01738
2·3	30·200	6·4	0·6919	10·5	0·01585
2·4	27·550	6·5	0·6310	10·6	0·01445
2·5	25·120	6·6	0·5755	10·7	0·01318
2·6	22·910	6·7	0·5249	10·8	0·01202
2·7	20·900	6·8	0·4787	10·9	0·01096
2·8	19·060	6·9	0·4366	11·0	0·01000
2·9	17·380	7·0	0·3981	11·1	0·00912
3·0	15·850	7·1	0·3631	11·2	0·00832

Mag.	L. R.	Mag.	L.R.	Mag.	L.R.
3·1	14·450	7·2	0·3312	11·3	0·00758
3·2	13·180	7·3	0·3020	11·4	0·00691
3·3	12·030	7·4	0·2755	11·5	0·00631
3·4	10·965	7·5	0·2512	11·6	0·00575
3·5	10·000	7·6	0·2291	11·7	0·00525
3·6	9·121	7·7	0·2090	11·8	0·00478
3·7	8·319	7·8	0·1906	11·9	0·00436
3·8	7·587	7·9	0·1738	12·0	0·00398
3·9	6.919	8·0	0·1585	12·1	0·00363
4·0	6·310	8·1	0·1445	12·2	0·00331
4·1	5·755	8·2	0·1318	12·3	0·00302
4·2	5·249	8·3	0·1203	12·4	0·00275
4·3	4·787	8·4	0·1096	12·5	0·00251
4·4	4·366	8·5	0·1000	12·6	0·00226
4·5	3·981	8·6	0·09121	12·7	0·00209
4·6	3·631	8·7	0·08319	12·8	0·00190
4·7	3·312	8·8	0·07587	12·9	0·00173
4·8	3·020	8·9	0·06919	13·0	0·00158
4·9	2·755	9·0	0·06310		
5·0	2·512	9·1	0·05755		

Comparison of the R.A. and Decl. of Standard Stars observed at the Radcliffe Observatory, Oxford, in the year 1872, with the Tabular R.A. and Decl. of the same Stars from the "Berliner Jahrbuch." By Prof. Dr. F. Ph. Wolfers.

(*Communicated by the Radcliffe Observer.*)

Name of Star.	Num. of Obs.	R.A. 1872 Oxford.	R.A. 1872 Ber. Jahr.	O.—B.J.	Num. of Obs.	Decl. 1872 Oxford.	Decl. 1872 Ber. Jahr.	O.—B.J.
α Andromedæ	5	0 1 46·42	46·47	−0·05	8	+28 23 0·45	2·25	−1·80
γ Pegasi	7	0 6 38·78	38·85	−0·07	7	+14 28 17·31	18·96	−1·65
α Cassiopeiæ	1	0 33 15·61	15·36	+0·25	6	+55 50 3·43	6·19	−2·76
[β Ceti]	1	0 37 9·66	9·80	−0·14	1	−18 41 23·71	23·54	−0·17
α Arietis	4	1 59 57·70	57·73	−0·03	5	+22 51 21·16	22·17	−1·01
[γ Ceti]	2	2 36 40·15	40·24	−0·09	3	+ 2 41 41·68	41·84	−0·16
α Ceti	2	2 55 35·39	35·41	−0·02	3	+ 3 35 9·69	9·37	+0·32
α Persei	—	...	...	...	15	+49 24 11·21	11·50	−0·29
α Tauri	4	4 28 34·69	34·69	0·00	7	+16 14 58·59	60·19	−1·60
α Aurigæ	2	5 7 13·98	14·23	−0·25	4	+45 51 53·68	53·74	−0·06
β Orionis	3	5 8 23·11	23·28	−0·17	2	− 8 21 6·13	5·65	−0·48
β Tauri	6	5 18 12·17	12·14	+0·03	15	+28 29 48·52	47·64	+0·88